

2.2 Sustainable value creation through innovative product design

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Abstract

In the field of product development, many organizations struggle to create a value proposition that can overcome the headwinds of technology change, regulatory requirements, and intense competition, in an effort to satisfy the long-term goals of sustainability. Today, organizations are realizing that they have lost portfolio value due to poor reliability, early product retirement, and abandoned design platforms. Beyond Lean and Green Manufacturing, shareholder value can be enhanced and optimized by taking on a broader perspective, and integrating sustainability innovation elements into product designs.

This paper presents a framework for achieving the goal of mutual value creation, and identifies the drivers of product design that are used to ultimately create what is termed - The Sustainable Products Value Proposition. Focus is placed on a balanced approach towards the integration of total cost of ownership, social and environmental improvements, and an expanded definition of product life drivers.

Keywords: Sustainability, Sustainable Value Proposition, Product Design, Product Half Life

1 INTRODUCTION

Technology advancements and new innovations continue to fuel the fast pace of new product introductions available to consumers around the world. In 1965, Gordon E. Moore predicted the number of transistors on integrated circuits would double every two years [1]. Today his relatively accurate prediction, better known as Moore's Law, serves as a symbolic backdrop for the exponential growth of consumer electronics as well as design evolutions in the majority of industrial categories. With each new product introduction, consumers are presented with such possibilities as increased productivity, improved communications and information flow, and even improved quality of life [2] [3]. But, with the ever increasing hunger for products that consume the world natural resources, questions arise of how to measure the benefits new technology brings to humankind vs. the potential wake of waste streams left in its path. The challenging concept is balancing the **e-gain** - benefits from new technology vs. the **e-waste** - of abandoned products. (see Figure 1)

To illustrate the affects of early product withdrawal, the study of the half-life of product families is introduced -- see Figure 2. The half-life is defined as the point where half of the products sold within a product platform (model family) are no longer used in the market. The graph presents models of relative half-life estimates for various types of material goods.

The chart exposes the challenges producers of consumer electronics and other high technology industries face where it is possible that the half-life of a product family is shorter than the time it took to develop the product. When product half-life data is superimposed on product financial models, even greater insight on the potential risk of early product abandonment is possible. The details behind these dynamics can aid in research towards the development of sustainable products and processes.

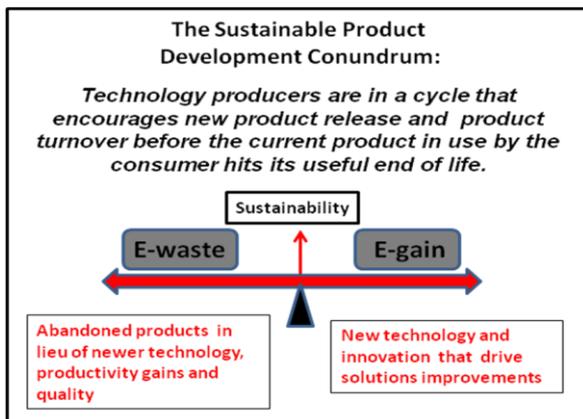


Figure 1: The balance between e-gain and e-waste.

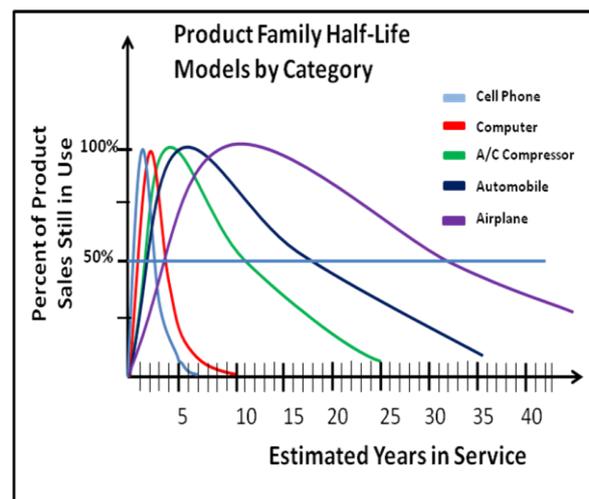


Figure 2: Relative product half-life curves of selected product families.

As a matter of strategy, engineers do not set out to design new products for the sake of creating waste, in fact producers face a new product development conundrum: *Technology producers are in a cycle that encourages new product release and product turnover, before the current product in use by the consumer hits its useful end of life.* In order to draw attention to the research necessary to help improve the development of sustainable products and processes, especially from a waste stream perspective, the perceived value should be well-understood and addressed.

Recently, there has been an increase in research centered on sustainable value [4]. In a paper by Ueda et. al. [5], value creation models were presented based on emergent systems and co-created decision making. This paper studied the relationships between natural, social, and artifactual systems. In related research, Tolio et. al. [6] focused on the complexity of economic, socio-political and technological dynamics. We focus our attention on the cost drivers of a sustainable value proposition used to develop products and drive innovative solutions --- see Figure 3.

With the help of NGO's, industry representatives, and government employees, influence on the long-term effects of sustainable products have increased in some industries. The potential for even greater value creation is not only possible, but also necessary, for improving sustainability in products from generation

to generation. At the heart of this proposition is the creation of mutual value between consumers and producers, as well as society and the environment.

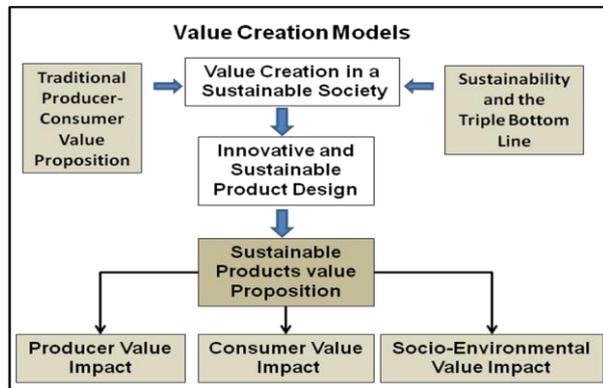


Figure 3 : Sustainable value creation framework for products.

In this paper, we identify the high impact drivers for each pillar of the Sustainable Value Proposition. In doing so, the design engineer will have a set of metrics that will aid in the optimization of value creation in generation-to-generation product development.

2 BACKGROUND

According to an ASME survey focused on the trends related to sustainability in product development, the overriding reason why corporations integrate sustainability factors into their designs is due to government regulations [7] [8]. This report surveyed engineers for reasons why they would

consider sustainability in their product designs. In addition to regulations, rising energy costs and client demand rounded out the top three motivating factors to develop more sustainable products. Only 16 percent of respondents included the potential for improved return on investment. In a similar survey conducted by the MIT Sloan Management Review and the Boston Consulting Group, which focused on integrating sustainability into the development process, 45% of respondents report that they expected higher operational cost to take away from profits. Thirty three percent cited the administrative costs of sustainability programs would create additional losses [9]. The results of the surveys show that in order to keep the attention of the design engineer when developing next generation products, or grab the attention of the consumer in the purchase of their next solution, sustainable value must be reviewed from their individual as well as mutual perspectives.

The triple bottom line (TBL) of sustainable development focuses on meeting the needs of the present without compromising the ability of future generations to meet their own needs [10]. In the center of this focus is the concept of the three pillars of sustainability, which requires the reconciliation of environmental, social and economic demands within the context of development. While the engineering community is familiar with the TBL, many struggle to project the concepts onto their own work. In order to put focus on sustainable value, we look to identify the overlapping benefits between the producer, consumers and the socio-environment. An additional set of pillars is referred to as the Sustainable Value Drivers (Figure 4).

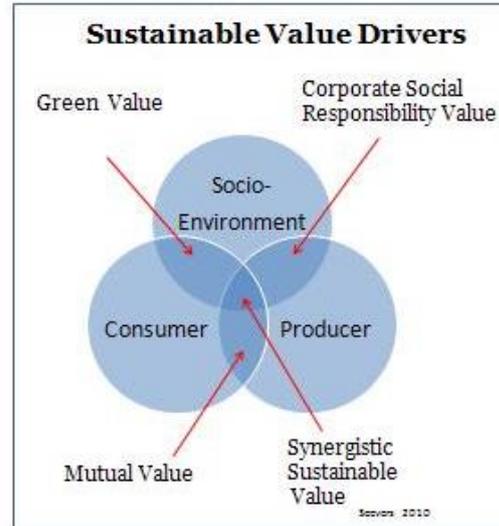


Figure 4: Sustainable value drivers.

New industries in **green marketing** have been created for consumers who seek out environmentally conscious products. Producers are motivated to show their social and environmental value through **corporate social responsibility reporting** (CSR). Consumers and producers often work together to create **mutual value** focused on solutions that reduce workflow and resource consumption. Yet, many engineers lack the tools or foresight to break the new product

design process down into the driving metrics that would seek new value creation for the consumer, producer and the socio-environment at the same time. In order to identify the driving aspects of the proposal, long-term value must be examined from each perspective.

Producer Value: In order for producers to be profitable, designers strive to develop products that meet customer needs at acceptable production and delivery cost – thereby creating a mutual value proposition. Product use and life are the key deliverables.

Consumer Value: Potential Customers seek out innovative solutions that meet their needs. In doing so, consumers weigh these potential solutions against the total cost of purchasing and owning the product.

Socio-Environmental Value: From a sustainability perspective, new products or solutions that improve the health and well being of society without affecting the need of future generations to meet their needs.

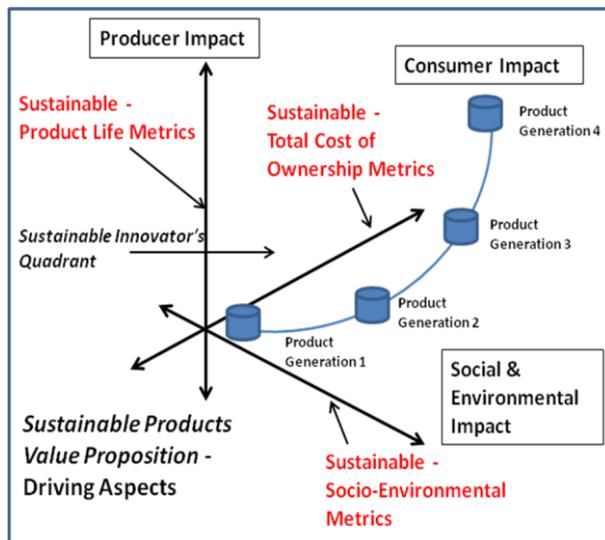


Figure 5: Sustainable products value proposition drivers.

These concepts are not difficult when studied on an individual basis, but creating solutions that optimize the three key pillars of design value is difficult. In fact, as the world becomes more competitive, the headwinds that development engineers face continues to complicate their ability to achieve the desired goal of sustainable development. For example, manufacturing losses, abandoned design platforms, and early product retirement are all examples of waste stream that create losses to producers, consumers, as well as to society and the environment. Certainly, research in topics focused on lean manufacturing and green marketing can help improve the bottom line. But, in order to have the greatest impact on the long-term development of products and processes, focus should be on developing a Sustainable Products Value Proposition that integrates sustainability innovation elements into the product design value proposition. These elements carry the design concepts beyond the traditional 3R's of reduce, reuse and recycle, to include recovery, redesign and remanufacture [11].

3 PRODUCER, CONSUMER AND SOCIO-ENVIRONMENTAL IMPACTS

One difficulty in developing a common set of aspects in the design of sustainable products and processes is the need to integrate a wide array of drivers into one common analytical metric set. In the process of identifying the driving aspects of the sustainable products value proposition, categories that have the highest impact from a value perspective are identified. In this process, value is viewed as the potential for new utility relative to its cost. In order to have the highest impact on the long-term goals of sustainability, generation-to-generation product designs should seek to improve each pillar of the driving aspects at the same time. (Figure 5) If design improvements are achieved in all three impact areas, the producers are developing products in the Sustainable Innovator's Quadrant.

A common paradigm of development engineers is the assumption that the bill of materials must increase in order to create solutions that accomplish goals such as extending life, meeting regulations, or lowering the cost for the customer to operate. In order to break down this paradigm, detailed drivers for each aspect are identified to provide a broader perspective to the key stakeholder of the value proposition. (Figure 6). The first step of this process is to broaden the definition of costs into a total life perspective. The concept of the total cost of ownership (TCO) has been presented in many forms including research and tools designed for analyzing business computing [12][13]. From a financial perspective, TCO represents the direct and indirect cost to purchase and utilize a product for the consumer. The sustainable products value proposition expands the set of total cost drivers.

3.1 Producer Impact: Cost of Product Development and Delivery

In general, consider the cost of these metrics to be the relative to the specific product design points chosen to meet the expected targets.

1. **Bill of Material Expense** – Typically, the primary focus of the development engineer from an expense perspective is the bill of material. This is the cost to physically manufacture the product.
2. **Relative Design concepts of delivered function, specifications and solutions** – In an effort to meet customer expected quality levels, features and functions, the engineering team creates the design specification that describes the expected outcome of the system. Typically, higher tolerances and tighter specifications can cost more to produce, but the customer may be willing to pay for it.
3. **Mean time between failure and Intervention** – The most common measure of system reliability is the **mean time between failures**. The uptime of equipment can affect productivity beyond the individual user, if the product is involved with any type of work flow. As system complexity as well as competition increase, another reliability-based metric, has become critical for the development

community. **Mean time between interventions** is also a measure of product up time, but it assumes that the system needs attention from the user (and not a warranty call). Examples in this category include clearing systems hangs/jams, changing supplies or updating the system. Complex solutions in the future will have longer lasting sub-systems, and will have intelligent operating and embedded systems.

4. **Cross Platform Compliance within Product Families** – This category is focused on the typical struggles producers face in the quest for satisfying the needs of individual customers vs. the financial benefits of focusing on the convertibility or the commonality of components or sub-systems between platforms. The ability to convert products already produced increases the value and flexibility of the supply chain team. Increasing the use or re-use of common sub-systems reduces the amount of development and verification resources required to design the product. This aspect is not only one of the key drivers that producers can use to reduce the cost of their value proposition, but it also applies directly to the improvement of the product family longevity, a key component of the environmental pillar.
5. **Generation-to-Generation Product Compliance** – The focus of this category is on enabling the producer to use existing infrastructure and intellectual property in the development of the next generation solution. Likewise, enabling the customer to use existing infrastructure and intellectual property in the transition and integration of the next generation system. Extending the platform of a product family through generation-to-generation compliance can have one of the most positive effects on designing sustainable products. This aspect is simple in concept, but becomes difficult when you integrate challenges from competitive designs, as well as the tendency of engineers to invent new systems because they can.
6. **Product Life Extension or Retirement** – This can be a cost stream or an opportunity for re-designing or re-manufacturing the product for retirement or extended use. Either way, the development engineer takes end-of-life product aspects into consideration in the overall design. The ultimate expense for a producer can come from a consumer abandoning the use of a product before its useful end-of-life.

3.2 Customer Impact: Costs and Benefits to the Customer

Ultimately, in free enterprise markets, the consumer is the focal point of new products and the longevity of competing designs. Customers seek out solutions where they realize benefits relative to the cost of the product.

1. **Benefit of New Innovation and Solution Improvements** – This metric is counter to the others in that this driver is viewed as the aggregate benefits gained by obtaining the new solution. This can be quantified through a variety of sources such as productivity gains, improved quality or reduction in material consumption.
2. **Cost to Purchase, Install and Prepare for Use** – Beyond the initial box cost, many consumers fail to include the cost to install and create the infrastructure for new products. This includes the training and learning curve required to fully utilize the new solution. Many products are abandoned early due to a mis-match in customer expectations or skill levels.
3. **Cost of Consumables** – This expense stream covers the material or supplies needed to maintain the utility of the solution. They are typically referred to as customer replaceable units (CRU's).
4. **Cost of Maintenance and Product Intervention** – Consumers expect products to work, but understand interventions and maintenance of the system might be required. Yet, there is a cost to perform these activities that include expenses beyond the person performing the activity. Often workflow downstream is affected by the downtime of devices.
5. **Cost of Warranty Repairs** - This is the combination of warranty expense for the customer and producer, as well the cost, the consumer faces with product down time. In order to protect themselves, many customers purchase extended warranties as a precaution in case of unexpected failures.
6. **Cost of the End of Current Life Cycle** – Beyond the cost of product disposal, there is often expenses in the activities that lead to the purchase of new equipment, as well as the removal and possible accelerated capital expense write-off of previous equipment.

3.3 Social and Environmental Impact: Cost of Product Compliance and Natural Resource Consumption

In the process of developing new products, good stewardship of our natural resources is now recognized as cost savings opportunity in addition to what more potential customer are expecting to review in the purchasing cycle. Standard reporting and certification processes are integral to the development model.

1. **Total Energy Consumption to produce and operate** – Tracking the consumption of utilities in the manufacturing process is prudent. Focusing on the effects energy consumption has on the product design often yields opportunity for increased quality or yield. In addition, consumers now track the

energy consumption of products, and it is often a critical specification for customer purchase

requirements.

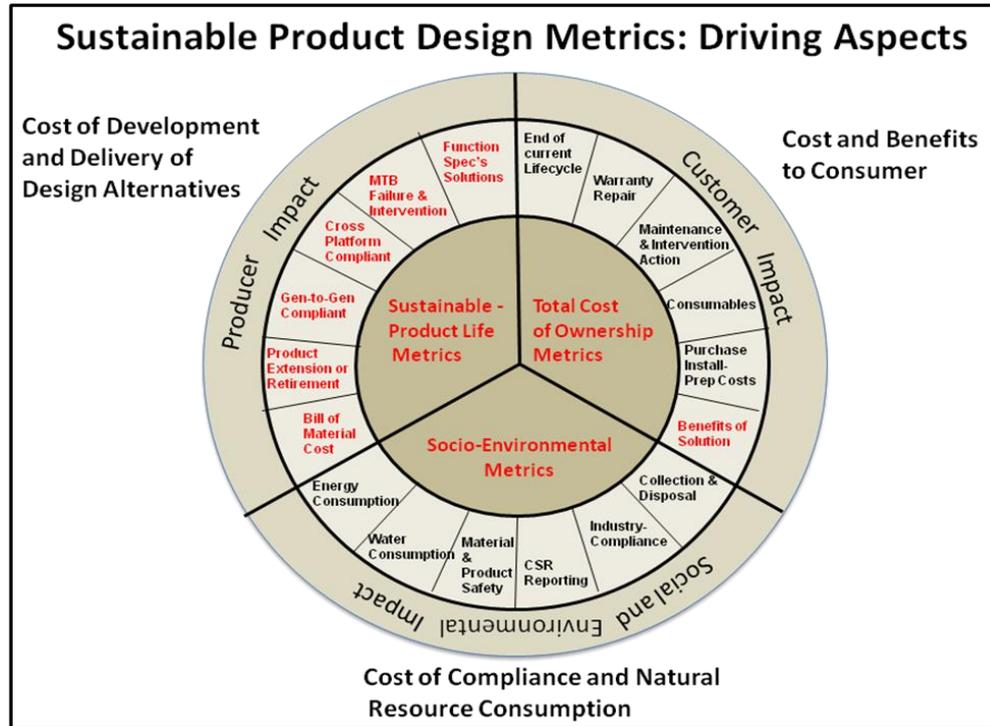


Figure 6: Detailed metrics of the cost/benefit drivers in the sustainable products value proposition.

2. **Total water consumption to produce and operate** – Energy consumption has been the central focus for engineers who seek to design for the environment. Now water consumption is also a critical aspect as the world's fresh water supplies become more acute.
3. **Product and Material Safety Compliances** – Most products require safety and material certification and approvals. In addition, depending on the product line, there can be a number of specific certifications required to sell to targeted consumers. This could include, energy, electromagnetic compatibility (EMC), acoustic or other aspects of products that affect society and the environment.
4. **Corporate Social and Environmental Activities and Reporting** – The health and safety of employees and consumers is usually first priority of producers. In addition, many corporations consider taking a proactive approach to social and environmental issues as a benefit to the overall value proposition. Today, many consumers look to producers to pass along sustainability-based metrics as part of the product delivery process.
5. **Industry specific certifications** – In addition to mainstream certification and regulatory requirements, many industries have specific

regulatory requirements that are aimed at the unique social and environmental aspects that the products may have.

6. **Collection and Product Disposal** - Many new regulations require producers to reclaim or at least play a role in the handling of products at the end of life.

4 SUMMARY

In free enterprise markets, producers seek to develop products that drive a profit for their respective business as well as provide the best solution for the customer. In this process, a value proposition is developed by the producer for the consumer that is designed to overcome the risks of the business venture vs. the potential reward for both the producer as well as the consumer. Products and design platforms that are abandoned before their useful life create waste and reduce asset value for society and the environment, in addition to the producer and consumer.

The sustainable products value proposition seeks a balanced approach towards the integration of total cost of ownership, social and environmental improvements, and an expanded definition of product life drivers. The driving metrics identified in the three impact areas are focused on reducing the potential risk of relative product offerings. In the development process, engineers need to not only look at the total cost for the consumer, but also take a broader and more holistic cost view in order to identify product designs concepts that may be at higher risk for long-term sustainability and waste

streams. This process is optimized, if it is conducted early in the development cycle,

The race continues between the e-gain benefits of new technology and the research for new tools that will aid in the long-term development of more sustainable products and processes. A central goal of this paper is to begin to build a new paradigm for development engineers, a paradigm that sheds light on the realization that product designs can be more sustainable from both a financial as well as environmental perspectives. By focusing on the main drivers of each sustainable value proposition aspect, the development community improves their role in creating truly sustainable value.

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